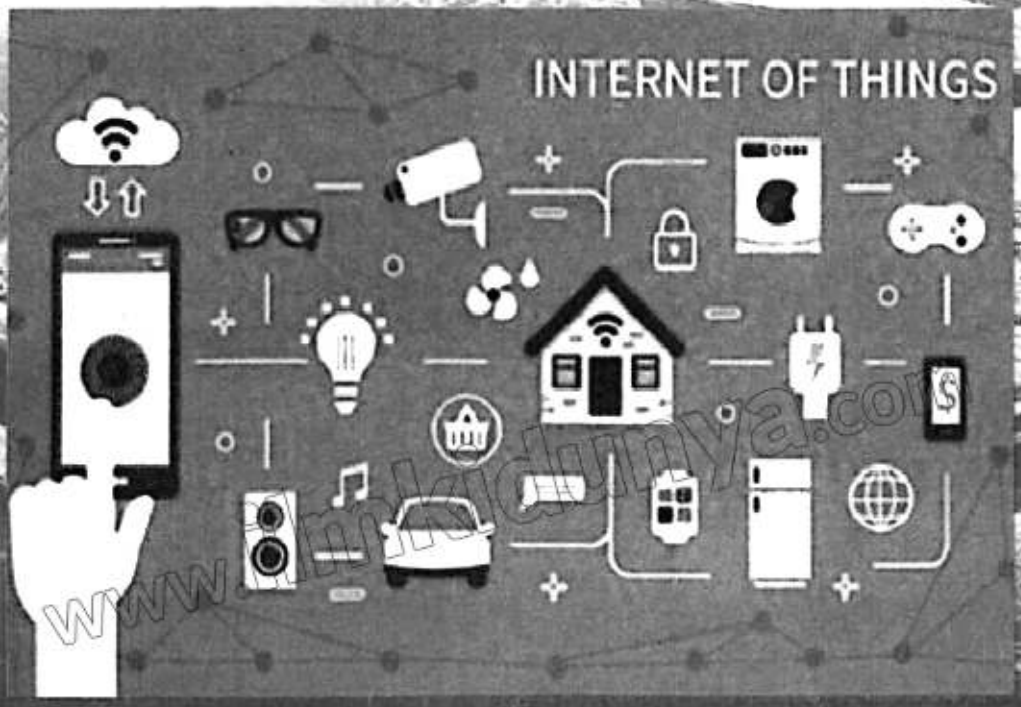
5 Applications of Computer Science

Learning Outcomes

At the end of this unit students will be able to:

- design ideas of applications relevant to Pakistan using IoT, Cloud Computing, and Blockchain.
- describe deep learning and its applications.
- assess policies that can help protect different stakeholders' interests.
- evaluate scenarios with data sharing and privacy conflicts and suggest policy decisions that can help achieve acceptable compromises.



5.1 Internet of Things (IoT)

IoT has big impact on today's modern society. In Pakistan it is at an early stages of planning and implementation. IoT technology improves productivity and efficiency in homes, offices and industries. Application of IoT in government and private sector in Pakistan will enhance our daily life by allowing us to perform daily activities with convenience and comfort. IoT technology provides enhanced automation, control, comfort and economical use of energy. Therefore, it is important to use IoT technology in Pakistan.

5.2 Designing IoT-based Applications

Today, there are billions of Internet-connected devices all overs the world and the number is rapidly increasing. IoT technology provides interconnectivity between various devices, machines and people through Internet that has resulted in innovations in many industries and organizations. Designing an IoT application means incorporating IoT technology into applications for specific purposes.

The following are examples of IoT-based applications.

5.2.1 IoT-based Air Pollution Monitoring

Pakistan is facing serious air pollution in big cities due to industrial emission, vehicle emission, brick kilns and seasonal crop burning. High level of air pollution is causing severe public health concerns such as respiratory and heart diseases.

IoT-based air pollution monitoring system integrated with cloud computing and Blockchain technologies can provide a solution to the environmental calamity of air pollution. It involves the following three stages.

1. IoT-based Real-time Data Collection using Sensors

Deploy a network of IoT sensors across a region having high level of air pollution to measure various pollutants like CO, NO2, etc., and environmental conditions such as temperature, humidity, etc. The sensors collect data and transmit it to a central network hub using wireless communication like Wi-Fi. The network hub sends the data to the cloud computing for storage and processing.

2. Cloud Platform for Data Storage and Processing

Use cloud platform such as AWS or Google Cloud to receive and store the massive amount of data collected by the IoT sensors. Cloud can also store historical data for trend analysis and forecasting. The cloud platform uses analytics techniques such as machine learning and data visualization to analyze and determine Air Quality Indices (AQI) in real-time. When pollution level exceeds certain level it generates alerts and notifications. Based on historical data and pollution patterns, cloud platform can also predict future air quality.

3. Blockchain for Transparency and Security

Create a Blockchain ledger to ensure integrity and authenticity of collected data. Blockchain technology will make the recorded data tamper-proof and less vulnerable to manipulation.

Finally, integrate the IoT sensors, cloud platform and Blockchain network by defining data formats, communication protocols and security measures. Develop user-friendly interface such as web dashboards or mobile apps to visualize air quality data and track trends and receive alerts.

5.2.2 IoT-based Flood Management

Floods are very common in some regions of Pakistan. Rivers and lakes overflow due to excessive rainfall. People lose their lives and there is significant property damage. We need a plan to minimize occurring of floods and damage caused by it by improving forecast, monitoring, and quick response to it.

Integrating IoT, cloud computing and Blockchain technologies can provide a powerful approach to flood management by real-time monitoring, data analysis and secure information sharing. This integrated system will allow for proactive flood risk assessment, early warnings and efficient response planning.

The following is a plan for flood management by making use of IoT-based monitoring integrated with cloud platform and Blockchain technologies.

1. IoT-based Real-time Data Collection using Sensors

IoT sensors can be deployed in flood-prone areas to monitor water levels, rainfall and other relevant parameters such as temperature, humidity, wind speed, wind direction and water temperature in real-time. The collected data is transmitted to cloud platform via wireless communication for analysis and further processing. Real-time data collection and uploading it to cloud platform is the core of the flood monitoring system.

2. Cloud Computing for Data Storage and Processing

Cloud platform provides a secure platform to store, analyze and process large volumes of flood-related data. Machine learning algorithms can be used to identify patterns and predict flood risks. Computer vision and image processing techniques can be used to create detailed maps of flood zones in real-time. When any monitored data exceeds the upper limit, the cloud platform will send alarm information to the administrator for quick response for timely evacuation and preparedness. Cloud-based platforms enable better decision-making and coordination among different agencies.

3. Blockchain for Transparency and Security

Blockchain technology can be used for secure record-keeping. It can create an immutable and transparent record of flood-related events. Blockchain can also be used in tracking the movement of relief materials, monitoring the progress of recovery efforts and ensuring that aid is delivered to those who need it.

Combining IoT, cloud computing and Blockchain for flood management provides proactive planning leading to better safety and reduced damage.

5.3 IoT Applications Applicable to Pakistan

5.3.1 Application of IoT in Agriculture

Agriculture is the backbone of Pakistan's economy. As the populations of Pakistan is increasing the demand for food is also increasing. We need to move from traditional agriculture towards smart agriculture based on IoT. It is essential to reshape our agricultural methods by using IoT technology.

The following are the benefits of smart agriculture.

- It allows farmers to have proper knowledge about climate by the use of sensors in IoT devices that observe real-time weather conditions.
- Data collected by sensors such as temperature, humidity, rainfall and soil condition makes farming more controlled, precise and efficient.
- Drones are used for monitoring crop planting, crop health and spraying fertilizer and pesticides and also help for irrigation.
- IoT-based farming will reduce production cost and contribute a lot in economical development.

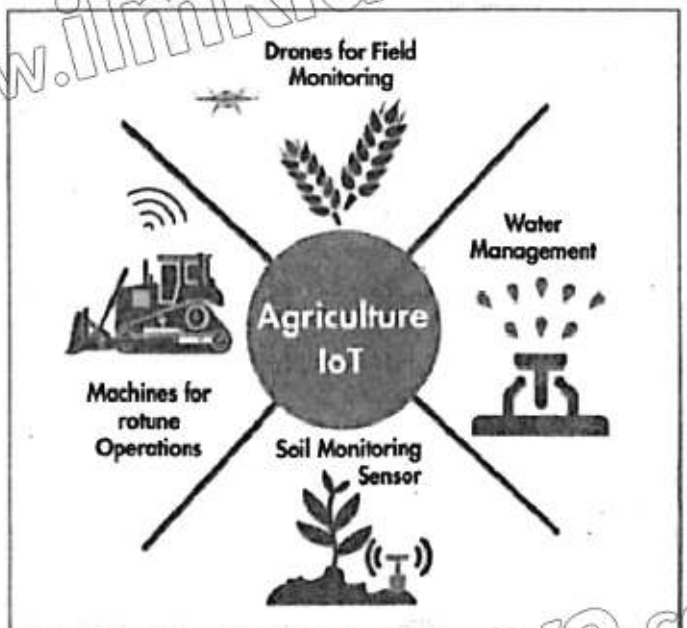


Fig. 5.1 IoT in farming

5.3.2 Application of IoT in Smart Grid

With high cost, shortage and growing requirements of electricity in Pakistan, we need IoT-based smarter solutions to optimize electrical usage and reduce consumer bills. To achieve this government needs to replace the old traditional grids with smart grids.

The infrastructure of electricity supply consists of transmission lines, transformers, substations and power grids. Smart grid also uses the same infrastructure but it involves IoT devices that can communicate with each other and with the consumers.

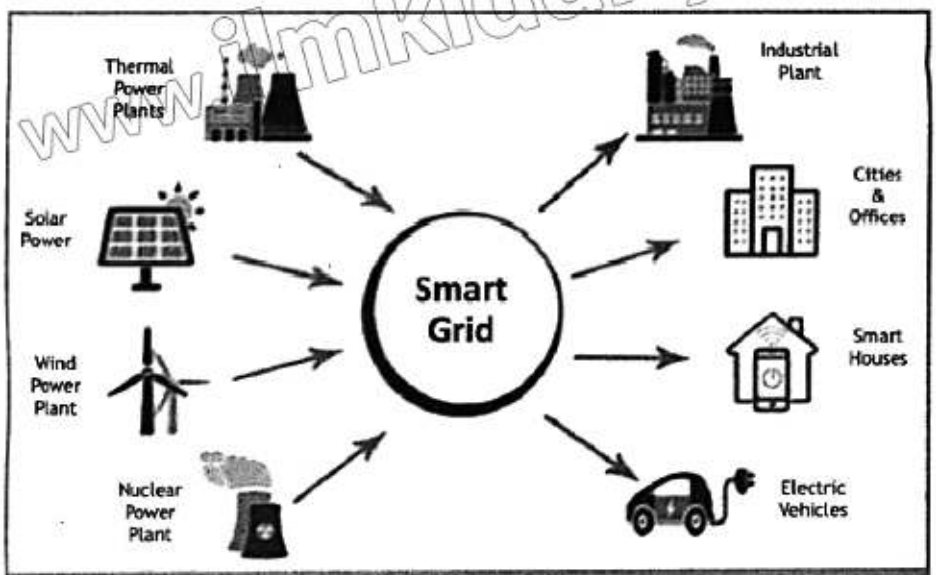


Fig. 5.2 Smart Grid

The following are the benefits of using smart grid.

- It provides more reliable power supply management by having better fault detection.
- It reduces power wastage by providing feedback to consumers on their electrical usage and ensures proper electric supply.
- It analyses the production of electricity and predicts when power shortage can occur so that power companies can take necessary steps to reduce the chances of it occurring.
- It can automatically reroute electricity when there is a power failure avoiding blackout of an entire area.
- It allows power companies to quickly restore power after power failure.
- During peak hours, IoT application suggests consumers to reduce power consumption.
- It generates more accurate bills.

5.3.3 Application of IoT in Traffic Management System

Traffic congestions, particularly in big cities in Pakistan are increasing with the ongoing population growth. Traffic congestions during rush hours cause more fuel consumption and wastage of time as well. This demands implementation of smart traffic management system that uses IoT technology.

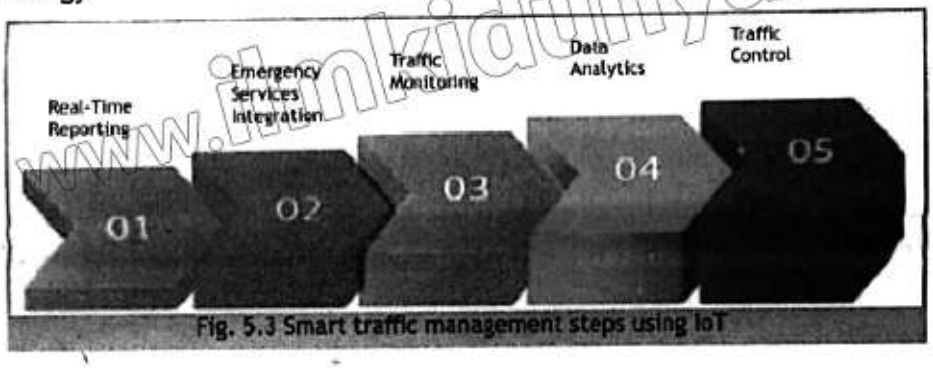


Fig. 5.3 Smart traffic management steps using IoT

The following are the benefits of application of IoT in traffic management system.

- Communication through Internet, computer networks and IoT devices enable the implementation of IoT based smart traffic management system.
- Sensors and IoT devices installed at traffic lights, roads and highways wirelessly collect real-time traffic data and send it to traffic control rooms to control traffic.
- It provides efficient traffic management by optimizing traffic flow.
- Reduces traffic congestions, improves overall road safety and reduces risk of accidents.
- IoT devices and sensors provide real-time information about road conditions to drivers and traffic control room for making better decisions.
- Informs drivers about congested areas and road hazards.
- Radio Frequency Identification (RFID) tags placed on the cars gain access to gated entrances. The purpose of using RFID tags is to save time through automation at gated entrances.
- Surveillance cameras can detect and capture images of traffic rules violators so that traffic authorities can take proper action against them.

5.3.4 Application of IoT in Healthcare Industry

IoT technology combined with AI are revolutionizing the healthcare industry all over the world. Advancement in healthcare has given birth to a new concept called Internet of Medical Things (IoMT). Healthcare is extremely important as heart problems, cancer and many other diseases are increasing in Pakistan, especially in big cities. There are many hospitals in Pakistan that are already equipped with IoT devices. We need to implement the IoT-based healthcare system in all the hospitals of our country to provide better healthcare service to the community. IoT improves productivity of doctors and medical professionals and provides efficient hospital workflow as well. It has many applications in healthcare industry.

The following are the applications and benefits of IoT in healthcare industry.

- IoT combined with AI is transforming the way patients' critical data is collected in healthcare industry. All the data collected is saved in cloud. Here, smart algorithms of machine language (ML) analyze the data for patterns to diagnose the disease, recommend medication or additional tests.
- IoT devices can track patients' blood pressure, heart beat rate, oxygen level, etc. in real-time. This information is used by medical professionals to monitor various health issues for proper treatment.
- Wearables equipped with sensors can be used for remote patient monitoring to provide medical care while patient is at home. Real-time patient tracking reduces unnecessary hospital visits and saves time and money.

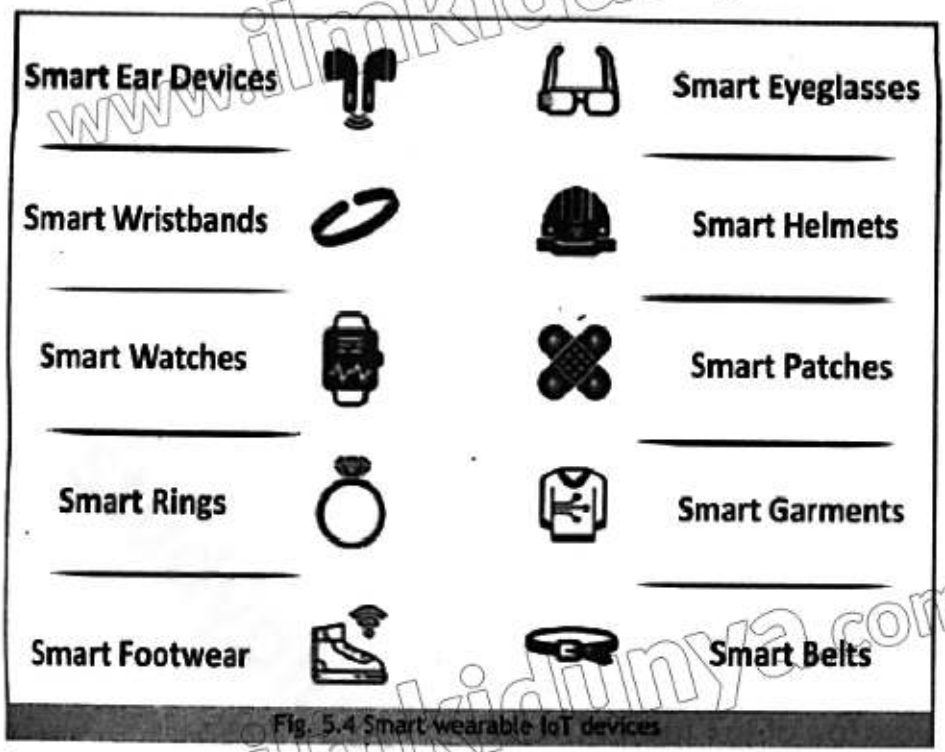


Fig. 5.4 Smart wearable IoT devices

- Modern hospitals are equipped with smart beds with various types of sensors to observe vital signs of patients in real-time. These sensors alert the nurse or doctor to urgently attend the patient if needed.

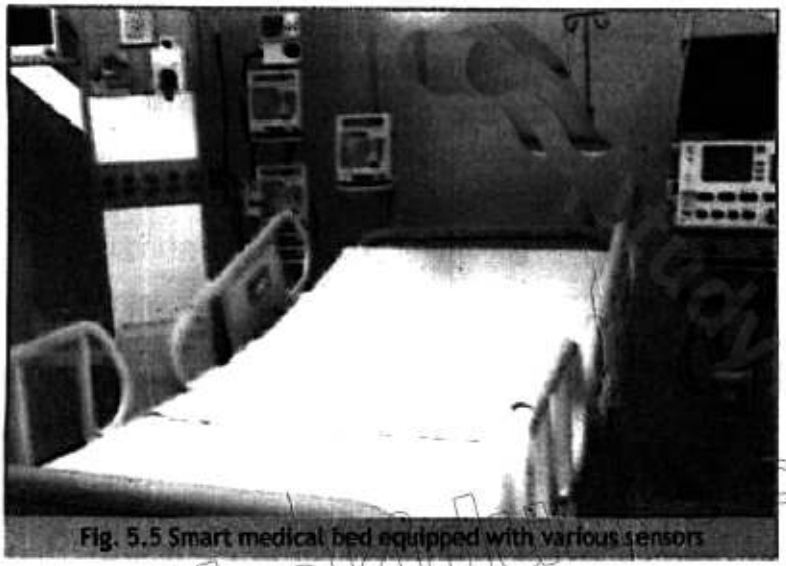


Fig. 5.5 Smart medical bed equipped with various sensors

- One of the recent developments in healthcare industry is introduction of smart ambulances fitted with various sensors. These ambulances provide diagnosis and treatment during transport to hospital in emergencies. In the past many patients have perished due to lack of required support system during transport. Ambulances fitted with sensors send critical data of patient to healthcare centers so that patient can receive proper treatment while remaining in the ambulance.

Fig. 5.6 Inside view of smart ambulance fitted with IoT sensors

5.3.5 Application of IoT in Manufacturing Industry

The future of IoT combined with AI is very promising in manufacturing industry. Today, big transformation in going on in manufacturing sector with the integration of IoT technology. It is essential to use IoT in manufacturing in Pakistan as well to improve efficiency, productivity and safety of workers and reduce production cost.

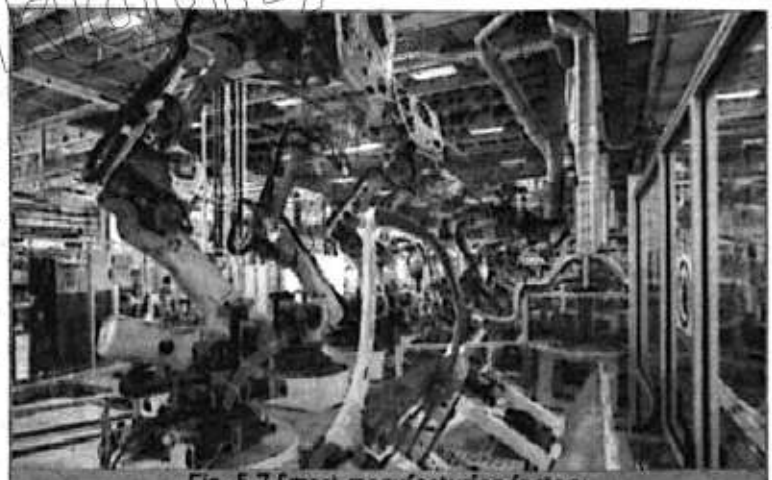


Fig. 5.7 Smart manufacturing factory

The following are the applications and benefits of IoT in manufacturing.

- It enables automation and optimization of processes involved in manufacturing.
- Large variety of sensors are used in a network to enable wireless communication between each other, collect and share data and efficent coordination of production activities.
- Robots are used to enhance accuracy and speed up manufacturing processes.
- It streamlines workflow in factories with minimal human intervention.
- Improves product quality using robotic systems, sensors, cameras and AI-based machine learning.
- Improves customer satisfaction by reducing defective products.
- Reduces workplace accidents and injuries caused by manual labor and risky tasks.
- Reduces product cost through automation, operational efficiency and reduction in labor cost.

- IoT combined with Blockchain technology enables efficient supply chain of products.
- Use of IoT devices in machines and other manufacturing equipment can reduce energy consumption which results in product cost reduction.

5.3.6 Application of IoT in Homes

Continuous developments and innovations in IoT has enabled the development of smart homes. Smart homes are residences equipped with IoT enabled home appliances connected to a central hub. The central hub receives data from sensors and processes it to take decisions. The appliances can communicate wirelessly with each other and the homeowners. IoT enabled devices in a smart home include TVs, ovens, washing machines, refrigerators, lights, fans, air-conditioning systems, security cameras, etc. In Pakistan some IT companies are providing services to transform traditional homes into smart homes.

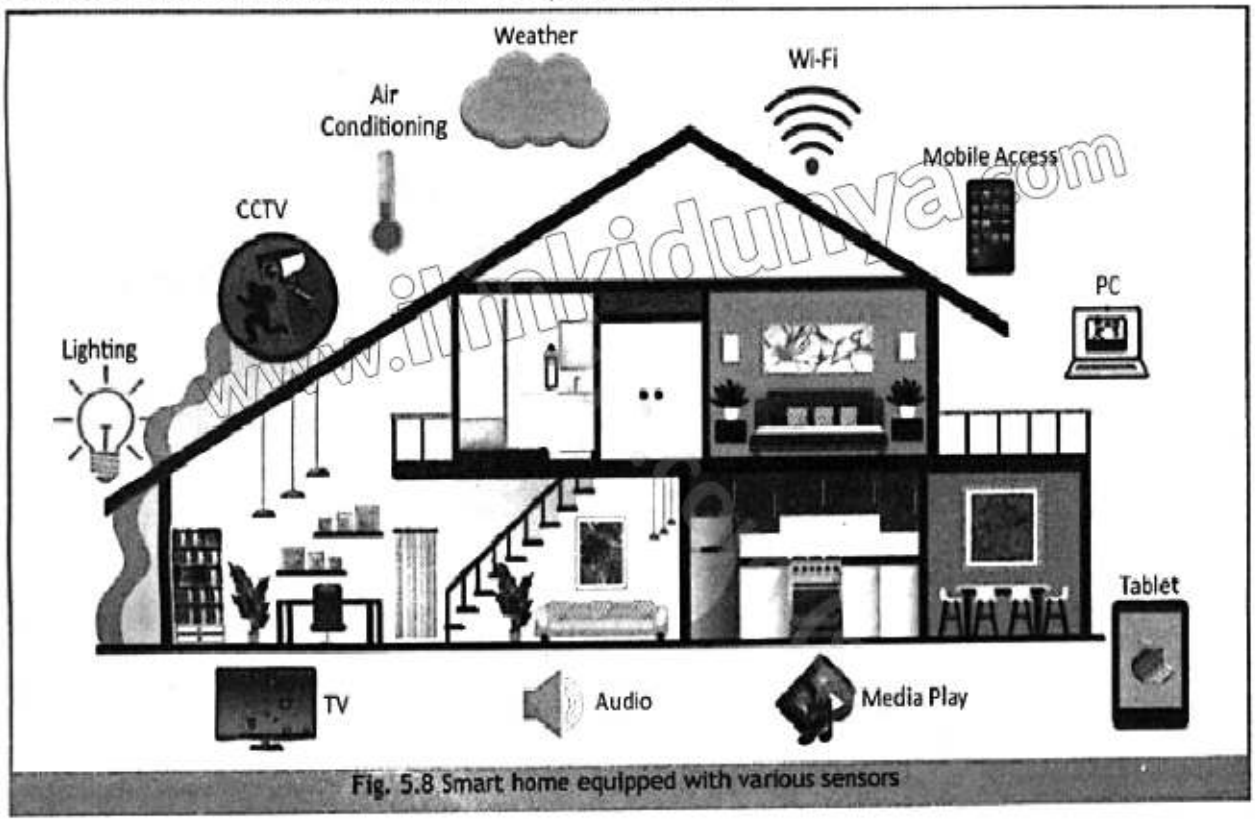


Fig. 5.8 Smart home equipped with various sensors

The following are the benefits of using IoT in smart homes.

- IoT provides convenience and efficiency in operation and control of home devices through smartphone or web interfaces providing better living environment.
- Homeowners can remotely control and monitor the devices when they are away.
- It reduces energy consumption resulting in reduced electricity bills. For example, sensors can detect whether a person is in the room or not and automatically turn on or turn off the air-conditioning or lights.
- Smart cameras, smart door locks, motions sensors and videos can alert the homeowner in real-time for security and safety.

5.3.7 Application of IoT to Control Air Pollution

Air pollution is one of the biggest problem in developed and developing countries. It is also a serious issue particularly in the metropolitan cities of Pakistan as health problems related with air pollution are growing at a fast rate. Air pollution is caused by dangerous gases emitted from industries, vehicles and homes. It causes heart diseases, lung cancer and eye irritation. It can also cause allergic reactions near the throat and eye.

IoT-based air pollution monitoring system can provide a solution to health problems related with air pollution. It collects data from various sensors in real-time and processes it for air pollution forecasts to see the trends and control it. IoT technology helps in taking intelligent and quick response for health and safety of community.

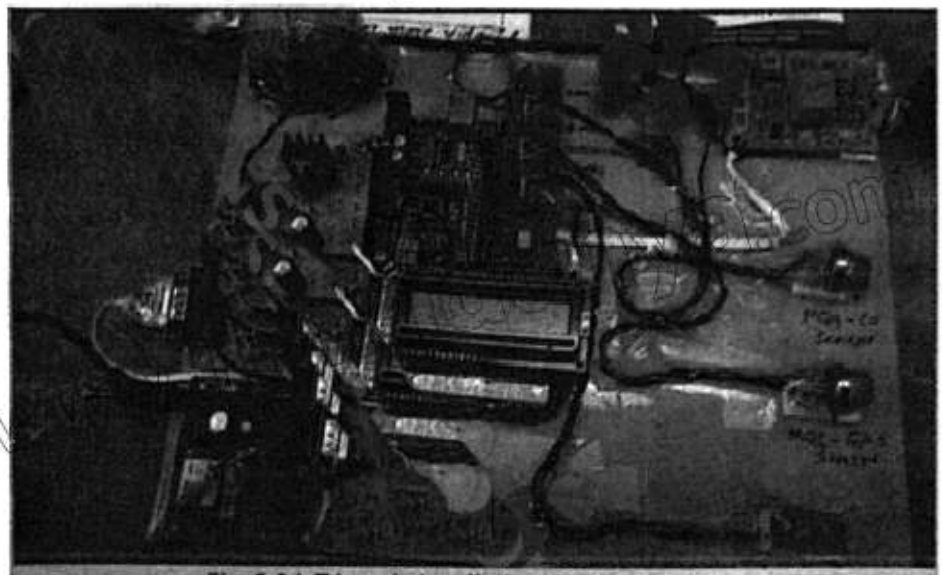


Fig. 5.9 IoT based air pollution monitoring system

5.3.8 Application of IoT in Natural Disaster Management

Natural disasters occur in many places and many people loss life. IoT can help in anticipating disasters and provide important information to emergency responders to effectively manage them. IoT devices play an important role in disaster management and planning to minimize the impact and protect infrastructure and loss of human life. Natural disasters include earthquakes, thunderstorm, floods and landslides due to heavy rains which are very common in Pakistan.

Fig. 5.10 Robot in earth quake rescue operation

Fig. 5.11 Landslides block Karakoram Highway

The following need to be implemented to manage disasters.

Real-time data collection and processing

IoT devices can collect environmental data that can be analyzed and processed to provide critical information. This information can help the concerned emergency authorities to take appropriate decisions according to the environmental conditions.

Monitoring infrastructure

The IoT devices embedded with sensors monitor infrastructure such as dams, bridges and buildings. The data collected from environmental conditions is used in decision-making to protect the infrastructure and save human life.

Search and rescue

Fig. 5.12 Pak Army in flood rescue operation

Fig. 5.13 Drone used for disaster rescue

IoT technology combined with rescue robots and drones equipped with cameras can help emergency responders take quick and effective actions in search and recue of human beings after disasters.

Pakistan National Disaster Management Authority (NDMA)

Pakistan NDMA formulates and enforces national disaster policies at federal and provincial levels. It collaborates with various government ministries, Pak Army and United Nations-based organizations to jointly coordinate efforts to conduct its disaster management, search and rescue and wide range of humanitarian operations in Pakistan and abroad.

Fig. 5.14 Pakistan NDMA Logo

Pakistan NDMA Disaster Alert Mobile App

Pakistan recently introduced the NDMA mobile application, designed to provide essential early warnings and advisories directly to users' devices. Developed by NDMA, this app aims to empower individuals and communities with vital information to effectively prepare for

and respond to potential disasters. The NDMA mobile app allows you to stay informed and safe at your fingertips.

Fig. 5.15 Pak NDMA Disaster Alert Mobile App images

5.4 Blockchain

A Blockchain application is a decentralized application developed on Blockchain technology. It is an innovative approach that relies on distributed ledger (database) of records or transactions that is shared among many network users. The ledger continuously grows as more records known as blocks are added. Blocks are chained together using cryptography to enhance security against data fraud and increase transparency. The use of distributed ledger ensures that once data is recorded it cannot be changed. This reduces vulnerability to cyber attacks. Blockchain provides reliable solutions across diverse industries.

5.5 Blockchain Applications Applicable to Pakistan

The following are some of the areas where Blockchain technology can be implemented in Pakistan.

5.5.1 Application of Blockchain in Voting

Pakistan has faced many issues related with traditional paper ballot system in the past. These

include allegation of rigging and manipulations. The use of Blockchain technology can transform voting system by ensuring security and integrity. Blockchain technology can help in voting by ensuring accuracy of voting process. The transparency and immutability of Blockchain can prevent any fraudulent activities. Voters can have confidence that their vote is counted and that the results are accurate. Blockchain can make the voting process more efficient and reduce cost as well.

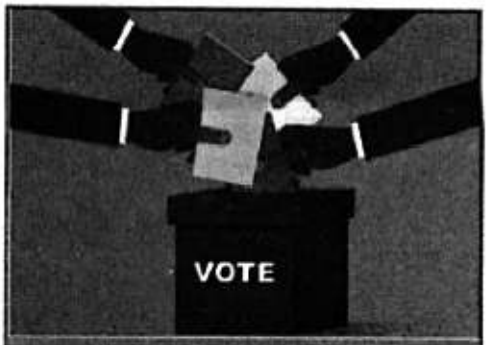


Fig. 5.16 Blockchain in Voting

5.5.2 Application of Blockchain in Healthcare

Most of the hospitals in Pakistan and worldwide face data security issues in healthcare services. Blockchain technology can revolutionize the way healthcare data is stored. Integration of Blockchain technology with healthcare services can provide increased privacy, transparency and accessibility for patient data. Sensitive medical data, diagnostic images, patient records and all the confidential information must be protected. Blockchain ensures data protection by cryptographic algorithms and the ability of immutability reducing the risk of data loss associated with unauthorized access and breach.


Fig. 5.17 Blockchain in Healthcare

5.5.3 Application of Blockchain in Banking Industry

The digital transformation of banking sector has provided smooth transactions and personalized services. Online banking has simplified daily transfers and transactions reducing frequent trips to banks or ATMs. This digital revolution in banking sector has many benefits but at the same time it has exposed banks to risks of data breaches and cyberthreats. These problems are faced all over the world in banking sector and in Pakistan as well. Blockchain technology integrated with cyber security can provide the solution to these problems. The innovative approach of Blockchain technology can make operation of banks more secure, transparent, efficient and cost effective and eliminate financial frauds.


Fig. 5.18 Blockchain in Banking

5.5.4 Application of Blockchain in Education

Blockchain technology having the capability of distributed ledger, enhanced security and transparency of records can be effectively utilized in Pakistan to solve various problems in education sector.

The manual system of keeping record of degrees, diplomas and certificates makes verification very time-consuming and difficult and can lead to use of fake credentials. The use of distributed ledger can make record-keeping more efficient, secure, transparent and also help in eliminating the use of fake credentials. It can make the verification process simple and easy as well.

Fig. 5.19 Blockchain in Education

Blockchain technology can also enhance the security and transparency of students' academic records, administrative process and accessibility of records. The adoption of Blockchain technology will allow students to have complete control over their academic records and certificates and degrees as it is saved on Blockchain instead of servers of educational institutions.

5.6 Cloud Computing

Cloud computing refers to the use of hosted services such as servers, data storage, databases, networking and software over the Internet. These services are maintained by cloud service provider and are available on demand. It allows users to save data, files, images, videos and software on the cloud and access these from anywhere with a laptop or desktop computer, mobile phone or tablet connected to Internet.

The following are some areas where cloud computing technology can be used in Pakistan to stay ahead in today's digital world.

5.6.1 Government and Public Sector

Cloud computing offers effective and secure platform to government and public sector to improve service delivery. Cloud-based solutions provide easy storage, access and analysis of vast amount of data. This helps government and public agencies to make more informed and coordinated decisions. It improves citizens interaction with the government by providing online services to conveniently and efficiently engage with the public.

Fig. 5.20 Cloud Computing in Government Public Service

5.6.2 Banking Industry

Cloud-based solutions minimize the need for expensive on-premise IT infrastructure in banking industry leading to significant cost savings. It has revolutionized the way banks operate, manage data and interact with customers. It enables banks to provide more personalized and efficient online services. It also helps in preventing frauds and cyberattacks.

Fig. 5.21 Cloud Computing in Banking

5.6.3. Education Sector

Cloud co ...uting improves overall institutional efficiency. Cloud-b- ...ed solutions streamline administrative tasks such a... student enrolment, grade management and attendance tracking. The online platform of LMS (Learning Management System) provides easy access to course material, assignments, assessments and announcements and efficient interaction with teachers and administrative staff. It enables online classes, workshops and training, saving costs.

Fig. 5.22 Cloud Computing in Education

5.6.4 Businesses

Cloud computing has revolutionized businesses. It enables businesses to store their data and applications on the cloud for easy access from any location. Mobile access to data via smartphones and other devices allows staff to keep instantly up-to-date with customers and co-workers. It reduces operational costs as businesses do not have to own, manage and maintain on-premise servers. It also provides more cost-effective cyber security for protecting data and applications stored on the cloud.

Fig. 5.23 Cloud Computing in Business

5.6.5 Transport

Cloud-based solutions facilitate intelligent transport systems that streamline operations, improve collaboration and enable adoption to new technologies. Cloud computing applications related with transportation improve fleet management, route planning and freight tracking. E-ticketing enhances passengers' travelling experience. It allows easy access to data and applications with mobile devices having Internet connection which enhances collaboration with partners and customers. Cloud computing makes transportation more efficient, faster, easier and reliable.

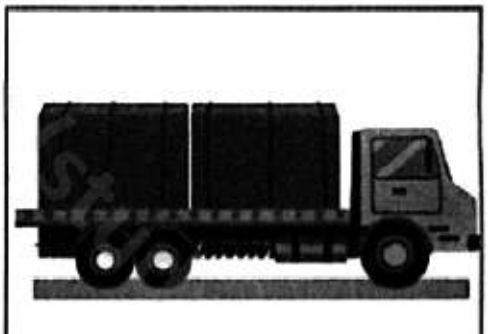


Fig. 5.24 Cloud Computing in Transport

5.6.6 Healthcare

Cloud computing has transformed the healthcare sector with valuable innovations. Cloud computing in hospitals makes it easy for doctors to view and share patients' medical records and update it in real-time. It helps doctors in providing better treatment based on comprehensive past history of patients. Telemedicine platforms enable virtual consultation with patients using

Fig. 5.25 Cloud Computing in Healthcare

video conferencing with healthcare providers remotely. It provides healthcare to patients unable to travel to hospitals. It allows patients to access their medical reports, lab testing reports and doctor's notes in real-time.

5.6.7 Media and Entertainment

Media and Entertainment companies are moving to the cloud technology as it provides them platform to deliver digital contents to their customers in an efficient and effective way. Cloud provides fast access to movies, songs and other digital contents from any location with an Internet connection. It allows Entertainment companies to deliver things on time and give users what they want. Media and Entertainment companies are using cloud platforms such as Netflix, YouTube and Spotify to adopt cloud technology and fulfill their customers' demands.

Fig.5.26 Cloud Computing in Media Entertainment

5.6.8 Software Development

Cloud computing provides on-demand computer resources such as storage and processing power to software developers to develop software. It provides significant cost savings for software development as it works on pay-as-you-go basis. Developers can add extra resources whey they are needed or remove unused resources to save costs. It allows software developers to collaborate in real-time from any location using cloud-based tools such as Dropbox and Google Drive for storage and file sharing. It speeds up the work involved in the development of software.

Fig. 5.27 Cloud-based Software Development

5.7 Neural Networks and Deep Learning

Neural networks and deep learning have some differences but they are closely related. Both of them are subset of Machine Learning (ML).

Machine learning is a branch of artificial intelligence that teaches computers to learn from data inputs and experience like humans without direct programming. Machine learning algorithms enable computers to train on data inputs and analyze it to produce accurate output. It recognizes patterns in large databases to build models to automate decision-making.

5.7.1 Neural Networks

Neural networks are simulations of working of human brain. They are based on the functioning of neurons in the human brain. It is a network of neurons that receive and send information throughout the network to make predictions and solve complex problems in a humanlike manner.

A neuron can be defined as a computational unit of a neural network.

Neural networks have layered approach to process information and produce output. Neural network comprises of the following three layers of neurons or nodes.

- **Input layer:** Input layer consists of one or more neurons. Each neuron receives raw data from the outside world. The raw data can be text, image, video, etc. The input data is passed on to the hidden layer. Each neuron of input layer represents a feature of input data.
- **Hidden layers:** There are one or multiple hidden layers which are between the input and output layers. Number of hidden layers and the number of neurons in each layer depend on the complexity of problem.
- **Output layer:** This is the final layer that produces the output. The output layer can have a single neuron or multiple neurons depending on the task. For example, for classifying whether an email is spam or not, the output layer will have only one neuron. Problems that require multiple output will have more than one neuron in the output layer.

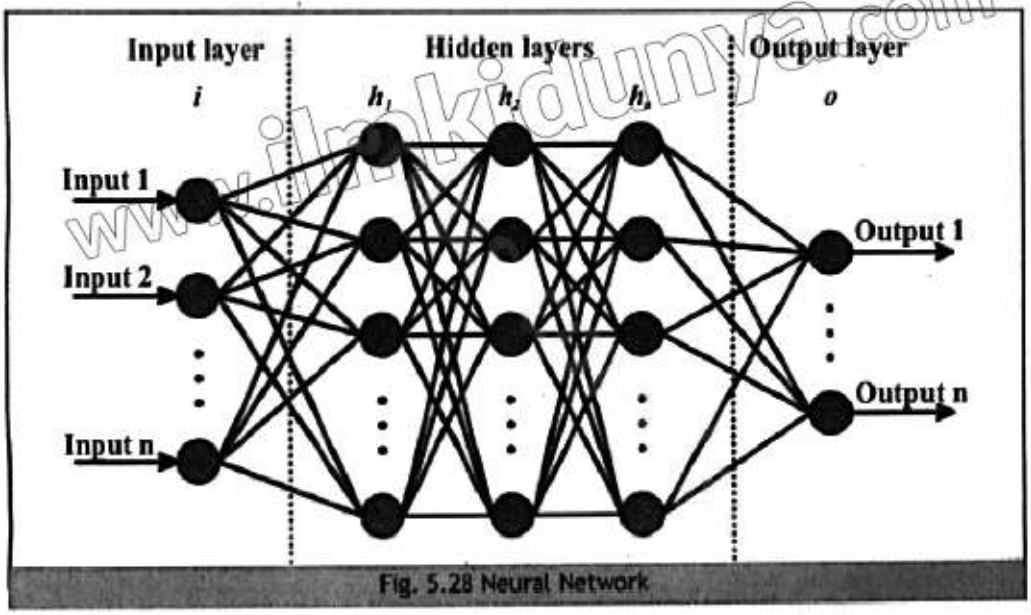


Fig. 5.28 Neural Network

Neurons of input layer receive input and pass it to the hidden layer through the synapse connection. Synapse is a small gap between the layers of neural network that allows information to pass from one layer to the next.

Weights

Weights represent numerical values associated with the connections between neurons. Weights determine the influence that one neuron's output has on another neuron's input in the next layer. Weights act as coefficients that can increase or decrease the importance of specific information. Weights are adjusted to minimize the difference between network's prediction and the actual output. The purpose of using weights is to fine-tune the neural network to make accurate predictions.

Biases

Biases are numerical constants associated with each neuron. Biases are added to neuron's output. The purpose of biases is to provide adaptability to ensure that the network can learn and make better predictions. Suppose a neuron processes the brightness of an image pixel. It will only activate when the pixel's brightness reaches a certain threshold. The bias can allow the neuron to activate even if brightness is below the threshold. Biases provide flexibility to neurons to activate in various input conditions. This helps in handling complex patterns in input data.

Activation Function

When a neuron receives input values, the activation function determines whether the neuron should be activated or not. In other words, the function decides if the input to a neuron is important in predicting the output. The activation function applies mathematical operations to weights associated with the inputs and outputs a value. If the output value of function reaches a threshold, the neuron is activated and the output value is passed on to the next hidden layer or used as final output. Otherwise, the neuron is deactivated and its value is not passed on. Activation functions are used in mapping the input values to a desired output in the last layer.

Loss Function.

Loss function determines how good a neural network model is in solving a problem. It means how well a neural network's predicted outputs match with the true outputs during the machine learning process. It evaluates the performance of a neural network model and helps in optimizing it by minimizing the loss. Minimizing the loss means reducing the mistakes on the learning data.

How a Neural Network is Trained?

Neural network models represent AI algorithms that accept a set of input data and predict output rather than directly implementing algorithms in programming languages. The neural networks learn through two processes known as feedforwad propagation and backpropagation.

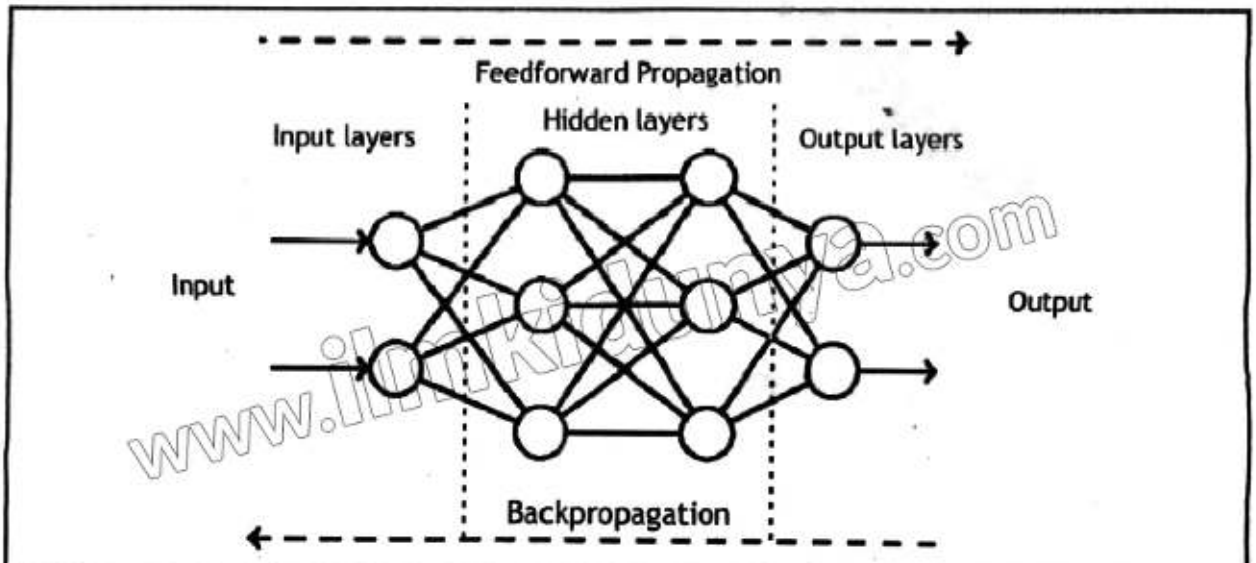


Fig. 5.29 Feedforward and Backpropagation Propagation

Feedforward Propagation

In feedforward propagation information is fed in the forward direction. It is passed on from the input data layer and then through the hidden layers and finally to the output layer. Neurons in each layer accept input data and process it using activation function. Based on the output values of activation function, it is decided whether the output values should be passed on to the neurons in the next layer or not. Those neurons whose output values are more than a certain threshold pass on the output value to the neurons in the next layer. Each neuron of a hidden layer receives input from the previous layer, processes it in the same way and passes on to the next layer till the final result is produced by the output layer.

Backpropagation

Backpropagation involves comparing the output produced by the output layer with the actual output. Loss function determines how well the network model is performing by matching the predicted output with actual output the network is meant to produce. The loss function is used to optimize the performance by minimizing the loss. The weights of the neurons are modified working from the output layer through the hidden layers and finally the input layer. The backpropagation causes the neural network perform better by reducing the difference between the actual output and the predicted output.

After the network has been trained with various sets of input data, it is ready to accept new sets of data it has never seen before and processes it to predict output.

5.7.2 Real-life Example of Application of Neural Network

The real-life example presented here is about evaluating the price of a house. There are many parameters that influence the price of a house. We are going to consider the following four parameters only to keep the example simple.

- Area (Square feet)
- Number of bedrooms
- Distance to city center (Km)
- House age

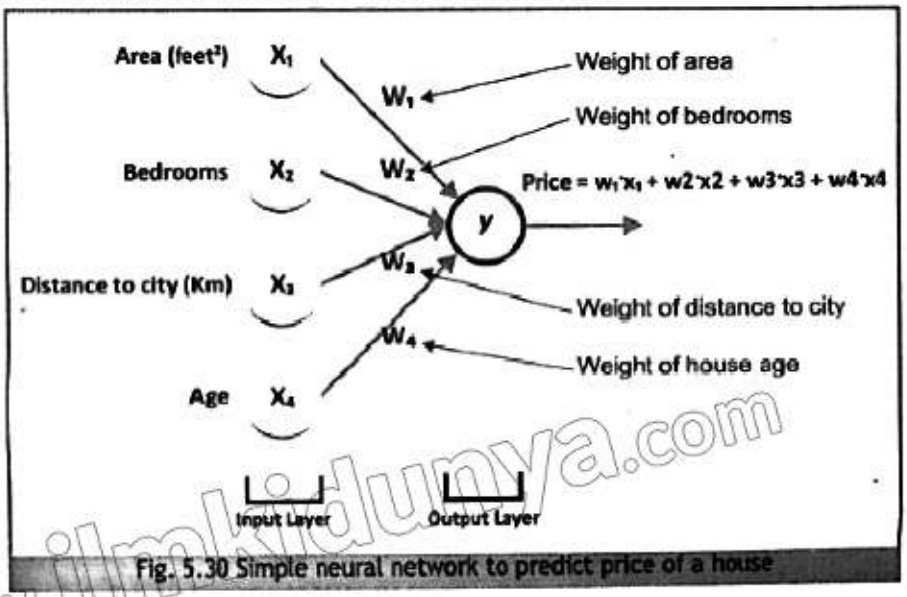


Fig. 5.30 Simple neural network to predict price of a house

A simple *weighted sum model* of neural network to predict the price of a house is shown in Fig.5.30. This neural network model can be trained to predict accurate result following the steps that have been described earlier.

5.7.3 Deep Learning and Neural Networks

Neural networks provide foundational building blocks for machine learning whereas deep learning emphasizes the depth of the neural network. Deep learning models employ neural network architecture. Therefore, they are often called deep neural networks. Without neural networks there will be no deep learning.

5.7.4 Deep Learning (DL)

Deep learning AI technology has revolutionized the world in solving complex problems. It uses deep neural networks to enable computers to autonomously extract hidden patterns and features from huge amount of data sets for making decisions. It provides human-like thinking ability for developing intelligent systems. Compared to machine learning, deep learning requires vast amount of data sets, takes more training time and requires high performance computers with GPU (Graphical Processing Unit). The GPU can process multiple data sets at the same time. Deep learning algorithms improve their decision making capabilities overtime as more sample data is input in the computer.

5.7.5 Applications of Deep Learning

Deep learning applications are used in many industries. Many people are using it in their everyday life. Following are some popular applications of Deep Learning.

1. Natural Language Processing (NLP)

NLP is an important application of DL. It allows machines to understand human language. It can interpret text and speech. DL-based NLP teaches computers and robots to provide suitable responses to linguistic inputs. Some widely used applications of NLP are language translators, sentiment analysis and customer service chatbots.

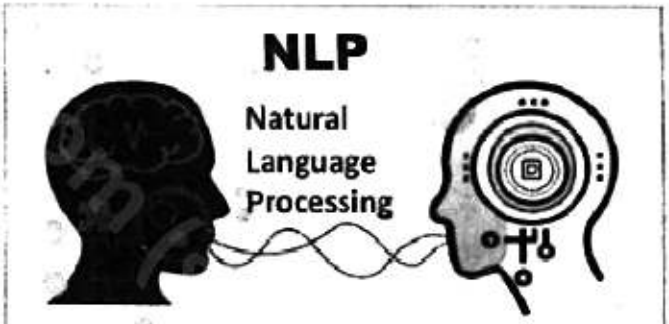


Fig. 5.31 Natural Language Processing

2. Healthcare

DL-based applications are extensively used in healthcare sector by medical professionals to achieve higher quality of service and provide better healthcare to patients. it is used for diagnosis of life-threatening diseases such as cancer and diabetic through medical imaging. It is also used for acute disease detection, smart health monitoring and medical research.

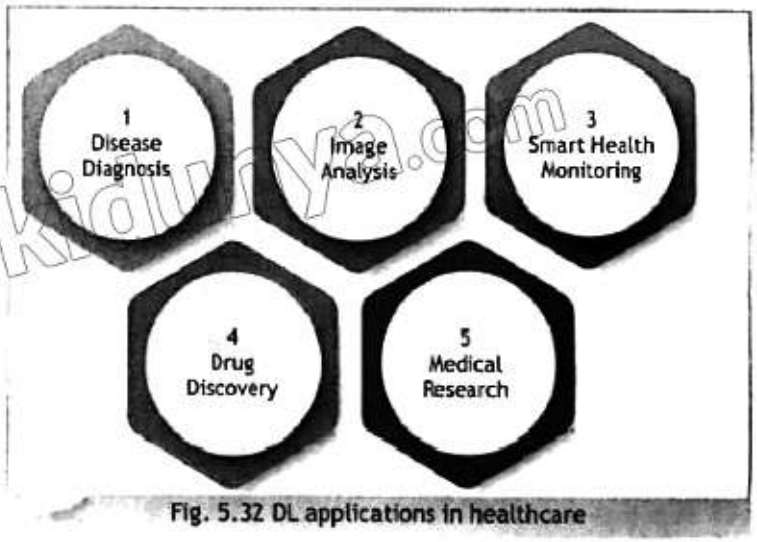


Fig. 5.32 DL applications in healthcare

3. Fraud Detection

DL can identify fraud and provide protection against it. For example, it can detect suspicious attempts to login into your account and inform you about it. PayPal used DL-based predictive analytics technology to detect and prevent fraudulent activity. DL has the ability to make fraud more predictable and avoidable.

Fig. 5.33 DL in fraud detection

4. Self-driving Car

Self-driving car is an autonomous vehicle based on DL technology that is capable of sensing its environment and operates without human involvement. It uses various sensors to calculate distance between nearby objects. It uses data from cameras, sensors and geo-mapping that enable it to detect traffic lights, recognize signs and avoid pedestrians. Self-driving car can be very helpful to particularly elderly and physically disabled people for travelling. Tesla is an example of self-driving car designed and manufactured by Tesla Inc.


Fig. 5.34 Self-driving Car

5. Robotics

Robotics is a branch of computer science and engineering that involves designing, development, manufacture and operation of a robot. DL technology is heavily used for building robots that can perform specific tasks with little or no human intervention. A robot has various sensors, cameras, microphone and it is controlled by a computer system. Robots are used in manufacturing industry, transporting goods in warehouses,

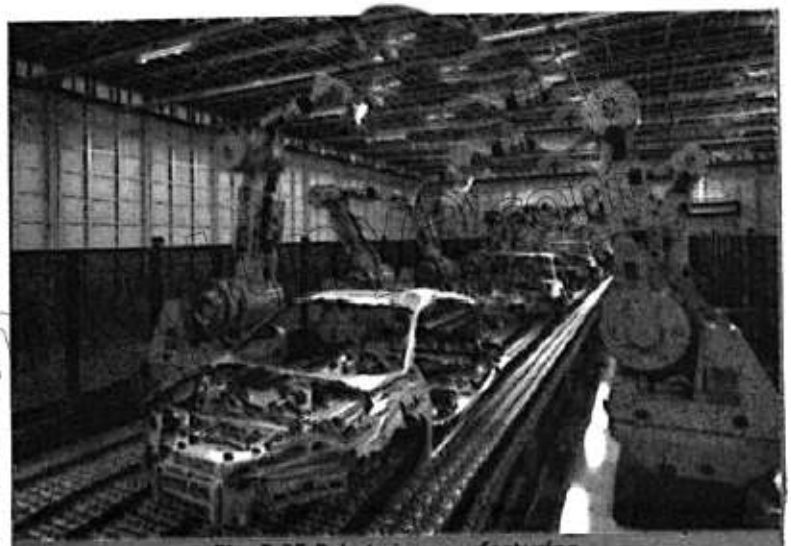


Fig. 5.35 Robots in manufacturing

hospitality industry, packaging medicine, performing operations, handling hazardous material, working in extreme temperature, etc.

6. Entertainment

DL applications are used in entertainment platforms for content personalization. DL-based algorithms can analyze vast amount of user data such as browsing history, preference, interests and behavior to provide personalized recommendations. Companies such as Amazon, YouTube, Netflix and Spotify provide personalized movies, songs and videos to enhance their customers' experience.

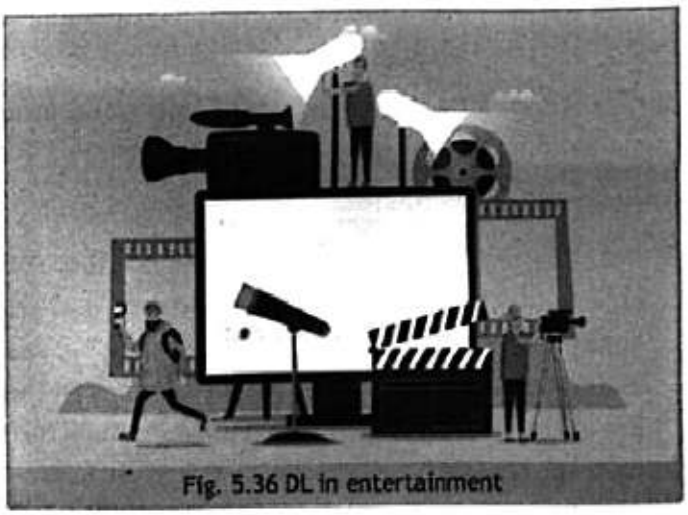


Fig. 5.36 DL in entertainment

5.7.6 Relationship Between AI, ML, Neural Network and DL

Although the relationship between AI, ML, Neural Network and DL are distinct but they form a close relationship.

- AI is at the core of the relationship used to create machines that can simulate human intelligence. There are many applications of AI. Some of these are Robotics, Computer Vision and Virtual Assistants.
- ML is a subset of AI that focus on the development of algorithms to learn from training data without explicit programming. Some examples of ML are Email Spam Filtering, Online Fraud Detection and Product Recommendation.
- Neural network is a subset of ML. Neural networks simulate human brain to develop algorithms that recognize patterns to help in making intelligent decisions. Examples of application of neural networks are image recognition, Stock Market Prediction and Weather Forecasting.
- Deep Learning is a specialized from of ML that uses neural networks with multiple hidden layers. It is particularly used in handling large datasets. Some of its applications are Language Translation, Natural Language Processing, Self-driving Car, Healthcare Diagnostics and playing strategic games such as Chess.

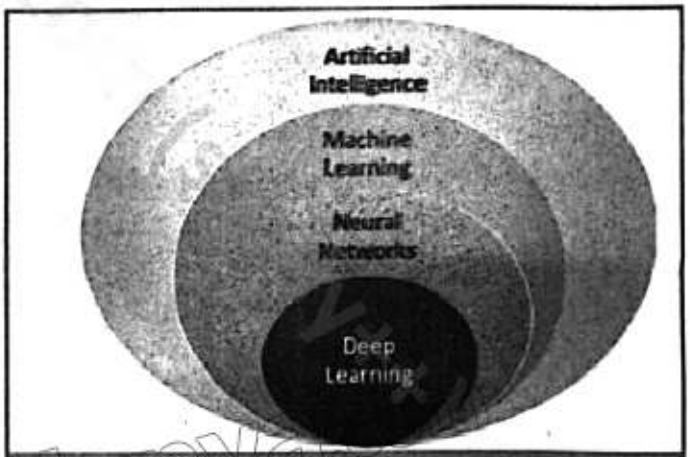


Fig. 5.37 Relationship Between AI, ML, Neural Network, DL

5.8 Data Sharing and Privacy

5.8.1 Data sharing

Data sharing means making the same data available to multiple users, applications and organizations. Data sharing has many benefits.

Benefits of data sharing

- Data sharing improves efficiency and collaboration within an organization, with business partners and with wider community. It promotes transparency, research and enables businesses to offer better services to the society. For example sharing data in health sector will be helpful in medical research to provide better healthcare services. Sharing result data by institutions will reveal their academic achievements.

Fig. 5.38 Data sharing

- Data sharing has significant positive influence on decision-making abilities of policymakers, managers and teams. Effective decision-making is essential for successful organizational performance.
- It allows to build relationship with customers. It improves marketing of products and services by reaching out people with right offer.
- Data sharing by government plays an important role in formulating public policies and planning delivery of services. Sharing the right data and collaboration among government agencies results in improving citizens lives.

5.8.2 Data Privacy

Data privacy generally means the ability of a person to control his personal information and get to know when, how and what personal information is shared with others. Data privacy applies to sensitive data such as Personal Identifiable Information (PII), Personal Health Information (PHI) and financial information of businesses and organizations. PII includes information such as names, ID numbers, email or postal addresses, birthdates and contact numbers. Sensitive data about employees, customers and shareholders plays an important role in operations and finances of businesses and organizations.

Fig. 5.39 Data Privacy

5.8.3 Data Sharing and Data Privacy Conflicts

With the increased use of Internet over the year, the importance of data privacy has increased as

websites, applications and social media platforms collect and store personal data about users to provide services. Ordering food online or purchasing items from online stores is very common for which people share personal information. Data sharing has many benefits but it comes with many risks and challenges. Organization need to identify the risks when sharing personal data and know who has access to it and how it is used. Shared data can be exposed to potential threats such as unauthorized access, misuse and theft. It is challenging to ensure that data is shared for the right purpose, particularly sensitive and confidential data. Unauthorized and illegal access to shared data can result in invasion of privacy, personal safety risk and it can also damage reputation. Thus, we can say that data sharing and privacy have conflicting requirements.

Fig. 5.40 Data Sharing and Privacy Conflicts

5.8.4 Misuse of Personal Data

Misuse of personal information can have very harmful consequences for individuals, businesses and the whole society. It is of the utmost importance for individuals, organizations and governments to maintain ethical standards and follow data protection regulations when collecting, sharing and processing personal information. Respecting others privacy rights when collecting personal information and ensuring ethical practices contributes to a more trustworthy and safe digital environment.

Fig. 5.41 Misuse of Personal Data

5.8.5 Safeguard Against Information Misuse

Data protection regulations have been put in place by governments all around the world. These include General Data Protection Regulations (GDPR) and the California Consumer Privacy Act (CCPA). GDPR has developed rules and regulations how the personal data of individuals in European Union (EU) can be collected, stored and processed. CCPA regulates that consumers should know what personal data is collected and gives consumers control over their personal data such as right not to disclose or sell it to others. Governments around the world may pass additional data privacy laws in the future as many people think that individuals do not have sufficient control over what happens to their personal data.

Fig. 5.42 Safeguard Against Information Misuse

5.8.6 Assessment of Polices to Protect Stakeholders' Interests in Data Privacy Conflicts

The following are the steps to assess data privacy conflicts among stakeholders and find its *practical solutions.*

1. Identify the Source of Data Privacy Conflicts

It is important to identify the root causes of data privacy conflicts for addressing these appropriately.

The following are the sources that can cause data privacy conflicts.

- Inconsistencies in organization's data governance policies. Data governance refers to how data is collected, stored and processed and who can have access to what kind of data.
- Conflicting standards and expectations related with data quality, security and accessibility among data users and providers. Data quality refers to data accuracy and reliability.
- Ethical and social issues related with collection, use or sharing of personal data.
- Different interpretations of privacy laws, lack of clarity in data handling policies or conflicting interests among stakeholders.
- Misunderstanding how data is being used.
- Different data protection laws and regulations in different countries and regions.

2. Negotiate and Compromise to Resolve Conflicts

The following are the important points to resolve conflicts.

- The stakeholders should negotiate trade-offs for their interests and objectives. They should establish common grounds to seek mutual agreement and compromise.
- Stakeholders should engage in dialog to understand each party's priorities and limitations.
- Stakeholders should balance the need for data access and usability with the need for data protection and encryption.
- They should balance the need for data completeness and accuracy with the need for data minimization and anonymization

Data minimization means to limit the collection to personal information to what is necessary to accomplish a specified purpose.

Data anonymization is the process of altering or removing personally identifiable information from datasets to protect privacy of individuals while enabling its utilization in software testing and analytics. For example, altering or removing the house number from the address of people so that they are not identifiable.

3. Implementing the Solutions

The agreed-upon solutions among the stakeholders should be effectively implemented to resolve data privacy conflicts.

- A data privacy framework should be adopted that implements all the aspects of data governance strategy.
- Data privacy tools such as data encryption, data loss prevention, firewall, etc. should be applied to control information that is being shared.
- Data privacy compliance should be monitored.
- Training programs should be conducted to engage employees at all levels in addressing concerns related with data sharing and gaining their support.
- Feedback should be taken from all the stakeholders for monitoring effectiveness of implementation of solutions and identification of areas for improvement.

5.8.7 Developing Data Governance Policies to Mitigate Data Sharing and Privacy Conflicts

Well-structured data governance policies are essential for handling data in compliance with laws and regulations. Conflicts in policies can cause confusion, inefficiency and even legal issues.

The following are the steps to develop policies for overall management of data collection, availability, usability, integrity and security in an organization.

1. Assess Context

The following points should be considered for assessing context.

- Assess the context in which the current conflicting policies were developed. Determine whether any policies are outdated or were developed for specific scenarios that no longer apply.
- Identify the reasons behind each policy and find out which aspects are open for revision and which are non-negotiable due to legal compliance.
- Determine the best course of action through assessment of the context in which conflicting policies were developed and what were their intended outcomes.
- Identify each policy's objectives and compliance requirements and analyze how they align with the overall goals of the organization.
- Involve the stakeholders to understand their point of view on each policy.
- Access the risks and benefits associated with each policy related with factors such as data privacy and security.

2. Identify the Stakeholders

Identify the stakeholders who will be impacted by the conflicting policies and who will have the authority to modify them. Stakeholders include department heads, IT security teams, legal advisors and any other relevant parties. Engage the stakeholders to get their perspective which is important for understanding the implications of each policy. This will help in building consensus, developing more balanced policies and make certain that all the issues are addressed and aligned with the organization's objectives.

3. Evaluate Risks

it is critical to assess risks associated with each policy. Evaluate the possibility of risks considering security of sensitive information, consequences of non-compliance with the regulations and reputational damage. Consult with stakeholders and legal advisors to get their perspective about risks associated with policies. Document all the decision-making process and clearly communicate to all the stakeholders to maintain transparency and accountability.

4. Propose Solutions

Propose solutions after analyzing the strength and weaknesses of each conflicting policy. Pay close attention to compliance requirements and organizational goals. Solutions may involve suggesting change to one policy, combining elements from two or developing new policy. Ensure that solutions are specific and actionable. Policies that are not clearly stated may lead to misunderstanding and confusion

5. Implement Changes

The final step is the implementation of solutions that have been agreed upon by the stakeholders. This includes updating documentation and communicating changes in the policies to all the relevant parties. This may also require providing training if needed. It is important to monitor the implementation of changes and obtain feedback to improve data governance within the organizations.

5.8.8 Principles adapted by Organization for Economic Cooperation and Development (OECD) on Data Sharing and Protection of Privacy

The OECD is an international organization of 37 member countries established in Paris in 1961. It was established to develop social and economic policies and international standards for better lives. It focuses on issues such as trade, environment, technology and education. Pakistan is not a member of OECD but has been regularly invited to participate in its meetings.

Fig. 5.43 Organization for Economic Cooperation and Development Logo

The following are the principles adapted by OECD on data sharing and protection of privacy.

- There should be limits to how much personal data can be collected.
- Personal data, when collected, should be accurate and related to the purpose it is being used for.
- The use of personal data should be specified.

- Data should not be used for purposes other than what was specified.
- Data should be kept secure.
- Personal data collection and usage should not be kept secret from individuals.
- Individuals have a number of rights, including the right to know who has their data, to have their data communicated to them, to know why a request for their data is denied, and to have their personal data corrected or erased.
- Anyone who collects data should be held accountable for implementing these principles.

Summary

- **Internet of Things (IoT)** is a network of physical devices having sensors such as smart phones, smart watches, smart security systems, smart home appliances, smart TVs and smart doors, connected through Internet for communication with each other.
- **Smart homes** are residences equipped with IoT enabled home appliances connected to a central hub. The central hub receives data from sensors and processes it to take decisions.
- The **NDMA developed mobile app** aims to empower individuals and communities with vital information to effectively prepare for and respond to potential disasters.
- **Blockchain** is a distributed ledger (database) of records or transactions that is shared among many network users. The ledger continuously grows as more records known as blocks are added. Blocks are chained together using cryptography to enhance security against fraud and increase transparency.
- **Cloud Computing** refers to the use of hosted services such as servers, data storage, databases, networking and software over the Internet. These services are maintained by cloud service providers and are available on demand.
- **Machine Learning** is a branch of artificial intelligence that teaches computers to learn from data inputs and experience like humans without direct programming. Machine learning algorithms enable computers to train on data inputs and analyze it to produce accurate output.
- **Neural Networks** are simulations of working of human brain. They are based on the functioning of neurons in the human brain. It is a network of neurons that receive and send information throughout the network to make predictions and solve complex problems in a humanlike manner.
- **Weights** represent numerical values associated with the connections between neurons. Weights determine the influence that one neuron's output has on another neuron's input in the next layer. Weights act as coefficients that can increase or decrease the importance of specific information.
- **Biases** are numerical constants associated with each neuron. Biases are added to neuron's output. The purpose of biases is to provide adaptability to ensure that the network can learn and make better predictions.
- **Activation Function** applies mathematical operations to weights associated with the inputs and outputs a value. If the output value of function reaches a threshold, the neuron is activated and the output value is passed on to the next hidden layer or used as final output.
- **Loss Function** determines how good a neural network model is in solving a problem. It

means how well a neural network's predicted outputs match with the true outputs during the machine learning process. It evaluates the performance of a neural network model and helps in optimizing it by minimizing the loss.

- In **feedforward propagation** information is fed in the forward direction. It is passed on from the input data layer and then through the hidden layers and finally to the output layer.
- **Backpropagation** involves comparing the output produced by the output layer with the actual output. Loss function determines how well the network model is performing by matching the predicted output with actual output the network is meant to produce. The loss function is used to optimize the performance by minimizing the loss.
- **Deep Learning** uses deep neural networks to enable computers to autonomously extract hidden patterns and features from huge amount of data sets for making decisions.
- **Data sharing** means making the same data available to multiple users, applications and organizations.
- **Data privacy** generally means the ability of a person to control his personal information and get to know when, how and what personal information is shared with others.
- **Data Governance** refers to how data is collected, stored and processed and who can have access to what kind of data.
- **Data Minimization** means to limit the collection to personal information to what is necessary to accomplish a specified purpose.
- **Data Anonymization** is the process of altering or removing personally identifiable information from datasets to protect privacy of individuals while enabling its utilization in software testing and analytics.
- The **Organization for Economical Cooperation and Development (OECD)** is an international organization of 37 member countries established in 1961. It was established to develop social and economic policies and international standards for better lives. It focuses on issues such as trade, environment, technology and education.

Exercise

Select the best answer for the following Multiple-Choice Questions (MCQs).

1. Which of the following technologies uses distributed ledger?
   a. Cloud computing
   b. Neural network
   c. IoT
   d. Blockchain
2. Which of the following is used for remote patient monitoring?
   a. Smart medical bed
   b. Smart wearables
   c. Smart ambulance
   d. Drone
3. Which layer feeds the raw data into the neural network?
   a. Hidden layer
   b. Input layer
   c. Network layer
   d. Output layer
4. Which of the following represents numerical values associated with the connections between neurons?
   a. Weight
   b. Biases
   c. Activation function
   d. Loss function
5. Which of the following decides if the input to a neuron is important in predicting the output?
   a. Weight
   b. Biases
   c. Activation function
   d. Loss function
6. Ability of a person to control his personal information is known as:
   a. Data protection
   b. Data privacy
   c. Data copyright
   d. Data transfer
7. Which of the following is used for training robots in performing complex tasks?
   a. Artificial intelligence
   b. Machine learning
   c. Neural network
   d. Deep learning
8. Which of the following alters personally identifiable information in datasets to protect data privacy?
   a. Data minimization
   b. Data anonymization
   c. Machine learning
   d. Deep learning
9. The technology used to enhance security against fraud and increase transparency is:
   a. IoT
   b. Cloud computing
   c. Blockchain
   d. Neural network
10. Which of the following focus on the development of algorithms to learn from training data?
    a. Robotics
    b. Natural language processing
    c. Machine learning
    d. Cloud servers

Give short answers to the following Short Response Questions (SRQs).

1. Give three reasons how IoT can reshape traditional agriculture and improve farming in Pakistan?
2. Describe three benefits of using IoT in manufacturing industry.
3. Describe how IoT can be helpful in controlling air pollution in Pakistan.
4. Describe the purpose of National Disaster Management Authority (NDMA) mobile app?
5. Differentiate between neural network and deep learning.
6. Briefly describe the applications of deep learning.
7. Describe three benefits of sharing data.
8. Briefly describe how personal data can be misused.
9. What are the benefits of using cloud computing in business sector?
10. Differentiate between data anonymization and data minimization with examples.

Give long answers to the following Extended Response Questions (ERQs).

1. Mention two applications of IoT technology applicable to Pakistan that are not presented in the text book. Why they are needed and what improvement they can bring?
2. Mention two applications of Blockchain technology applicable to Pakistan that are not presented in the text book. Why they are needed and what improvement they can bring?
3. Develop a simple neural network model to predict price of a smart mobile phone based on five specifications such as processor, camera, screen size, battery life, etc.
4. Mention four risks associated with data sharing and privacy in organizations.
5. Briefly explain how data governance policies can be helpful in mitigating data sharing and privacy conflict.
6. Mention five reasons due to which data privacy conflicts can arise among stakeholders in organizations in Pakistan.
7. Which principles should be adapted for data sharing and protection of privacy in Pakistan?

Activity 1

Case Study Analysis: Provide students with case studies of real-life scenarios that have data sharing and privacy conflicts, such as the Cambridge Analytica scandal, and ask them to evaluate the situation and suggest policy decisions that can help achieve acceptable compromises. This exercise will allow students to practice analyzing and evaluating real-world examples of data sharing and privacy conflicts and develop their critical thinking skills.

Activity 2

Debate: Divide the class into two groups and assign each group a stance on a data sharing and privacy conflict. For example, one group could argue that social media companies should be required to share user data with the government to prevent terrorism, while the other group could argue that this would be a violation of privacy rights. This exercise will allow students to practice arguing their points of view and develop their communication and collaboration skills.

Activity 3

Policy Writing: Ask student to work in groups to draft a policy document that outlines how organizations should handle data sharing and privacy conflicts. The policy document should consider the benefits and drawbacks of data sharing, as well as the importance of protecting individuals' privacy rights. This exercise will allow students to practice working collaboratively, developing policy proposals, and understanding the nuances of data sharing and privacy.

Activity 4

Create an activity that requires taking an example of data sharing and privacy conflicts in the news or online. Students evaluate the situation and suggest policy decisions that could help resolve the conflict.